

Simulation Studies for a GEM-based TPC

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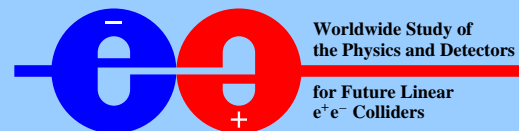
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ILC TPC Analysis Jamboree

13.2. - 15.2. DESY Hamburg

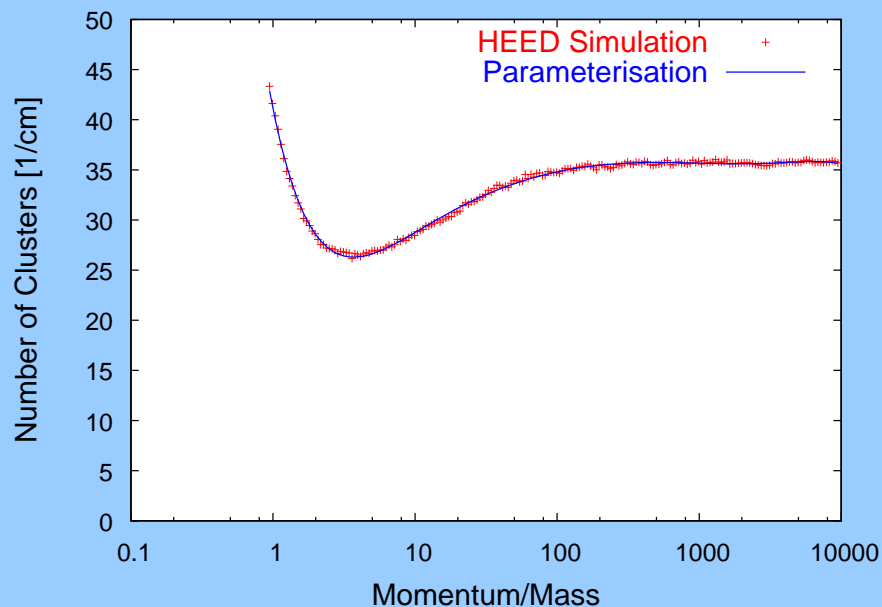


4 Modules:

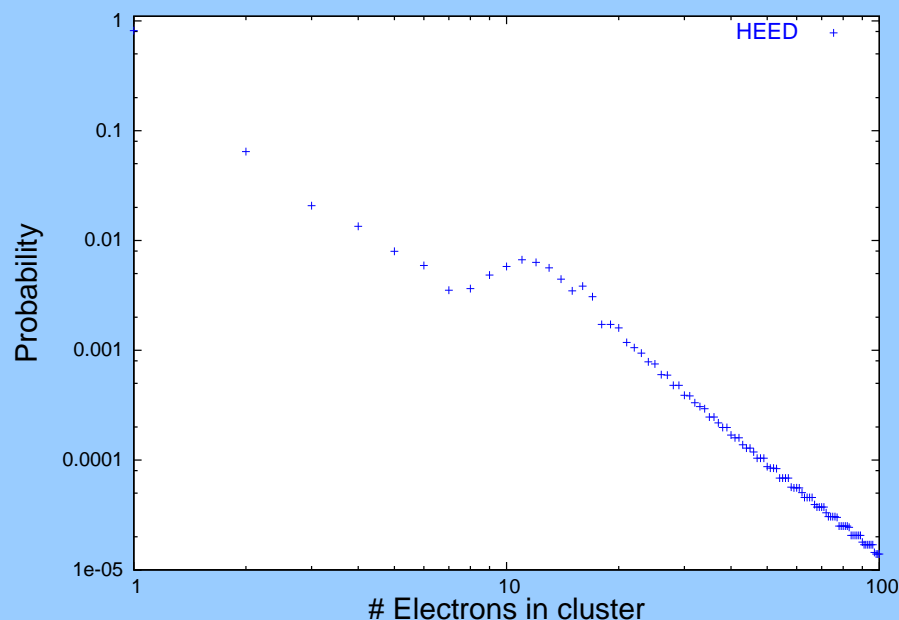
1. Primary ionisation
2. Drift of electrons
3. Gas amplification with GEMs
4. Electronics (shaper, ADC)

Goals: Study influence on the spatial resolution of a TPC of

- Electric and magnetic fields
- GEM settings
- Pad response, pad geometry
- Ion backdrift

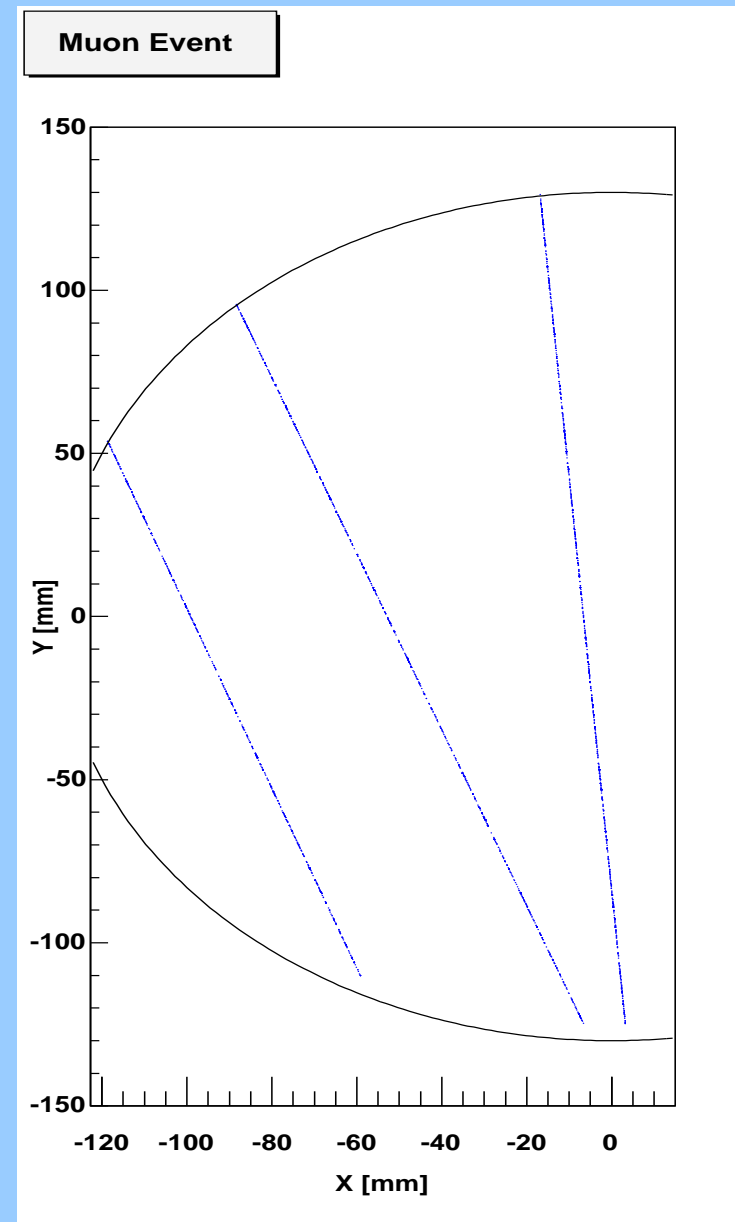
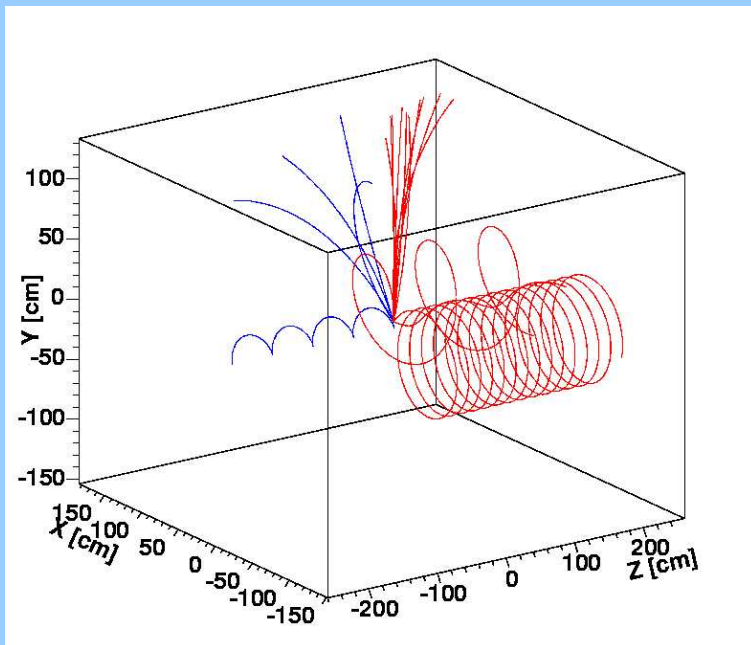


Mean number of clusters
→ Distance between clusters
from exponential distribution
with this mean value

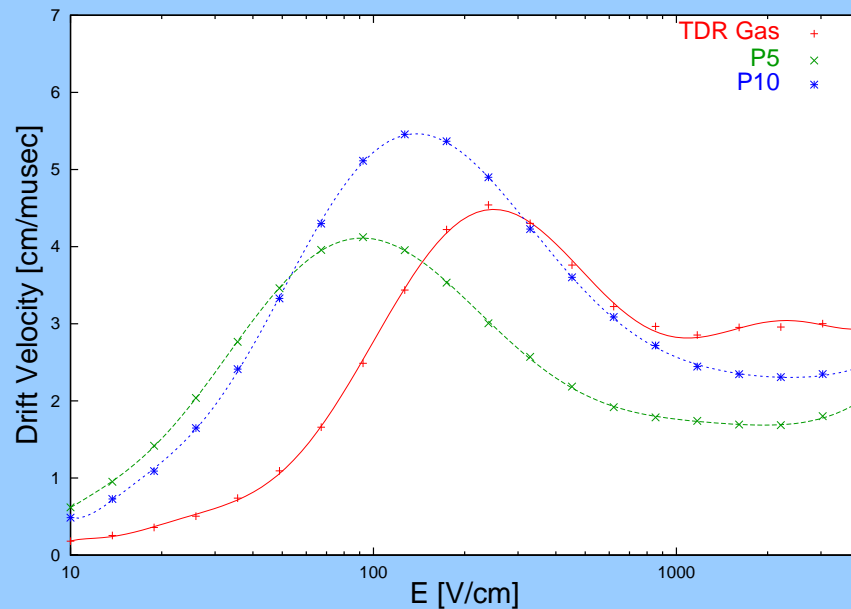


Probability for number of electrons
per cluster
→ Choose randomly according to
distribution

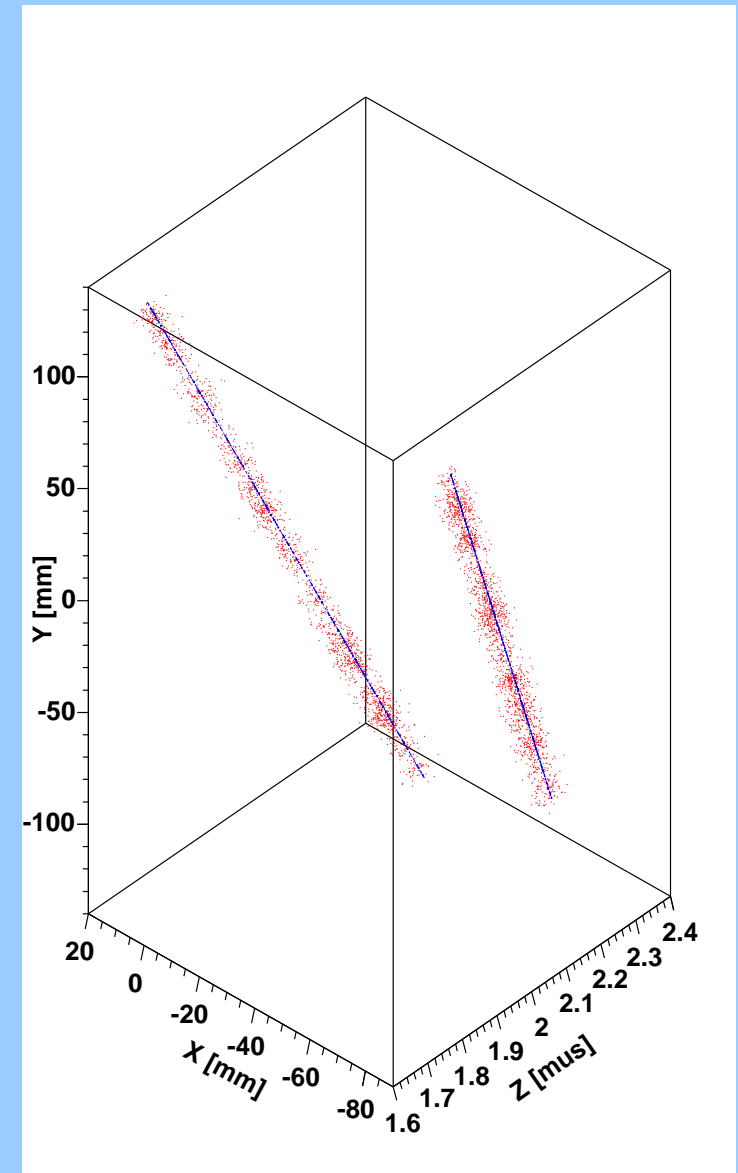
- Randomly choose distance to next cluster
- Choose # of e^- in this cluster
- 3D information possible
- B fields possible



Parametrise gas properties
simulated with MAGBOLTZ

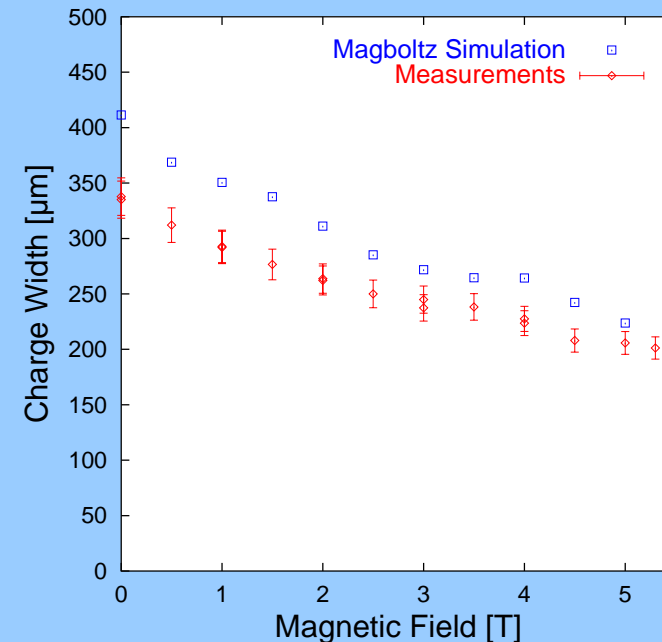
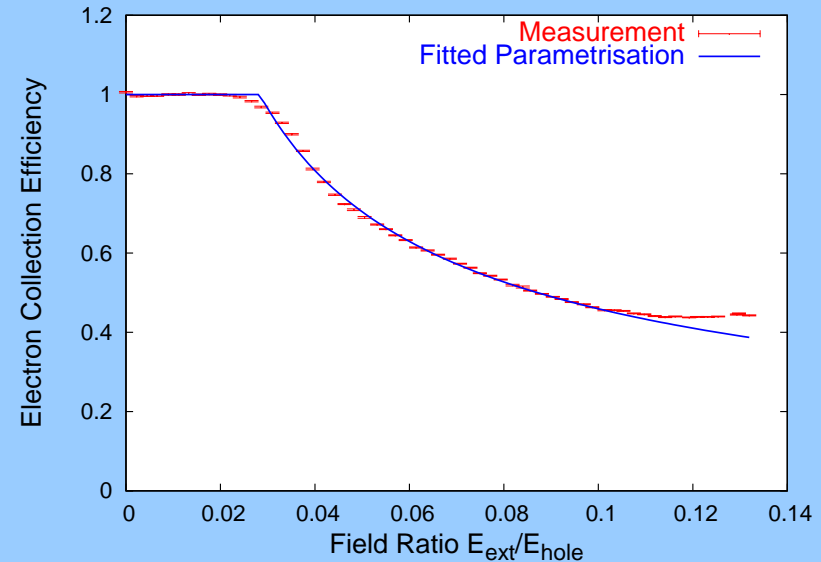


Dice coordinates after drifting
according to longitudinal and
transverse diffusion

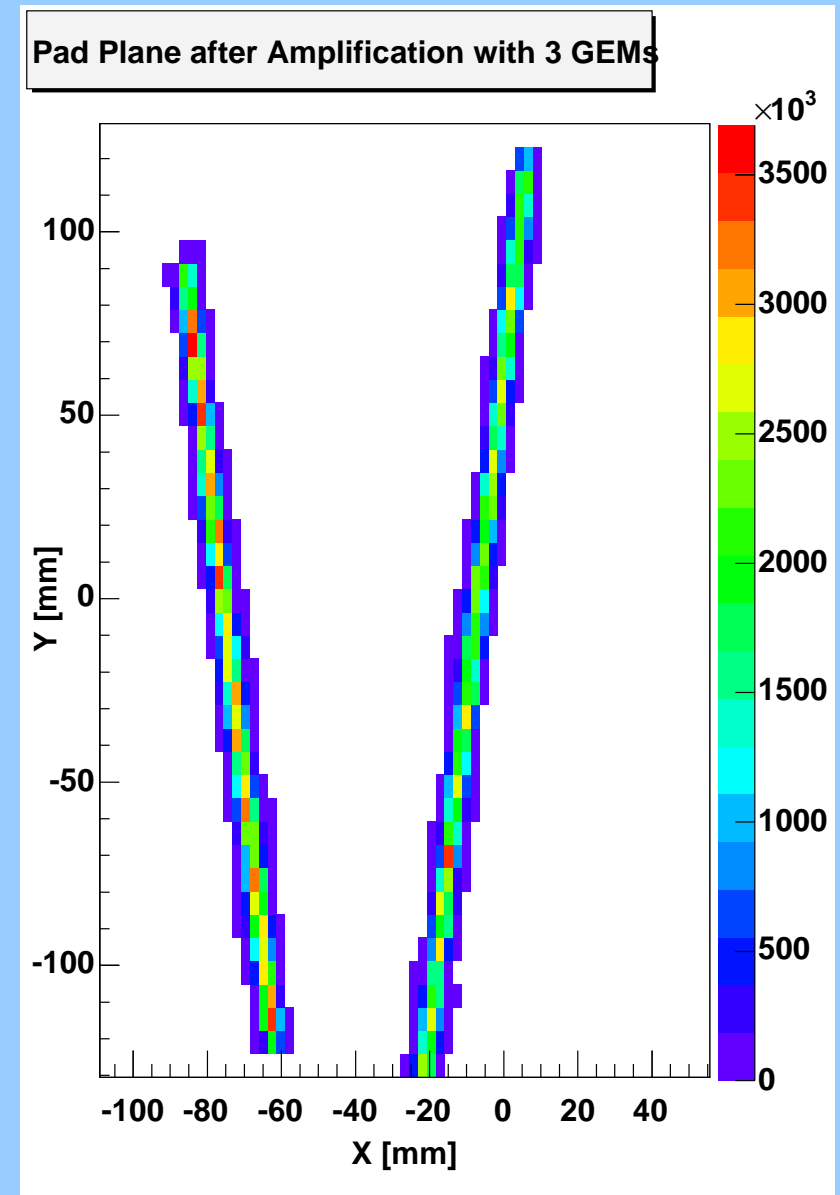


From measurements:

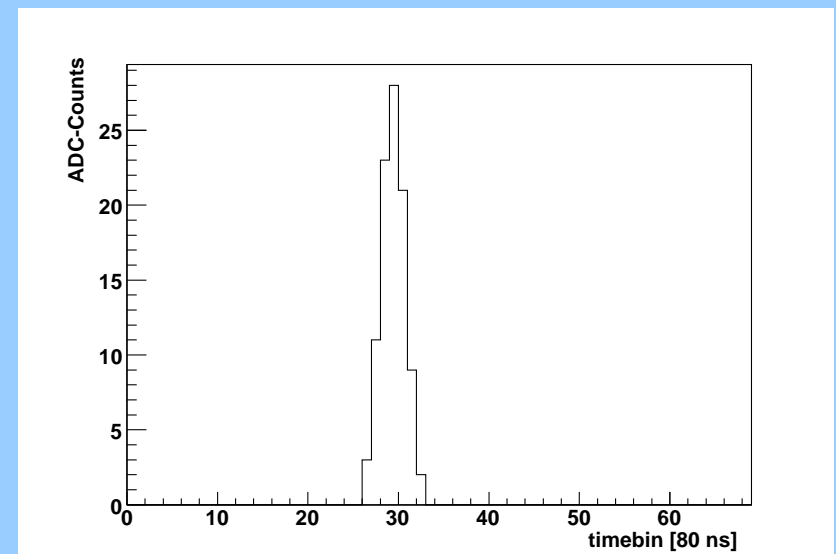
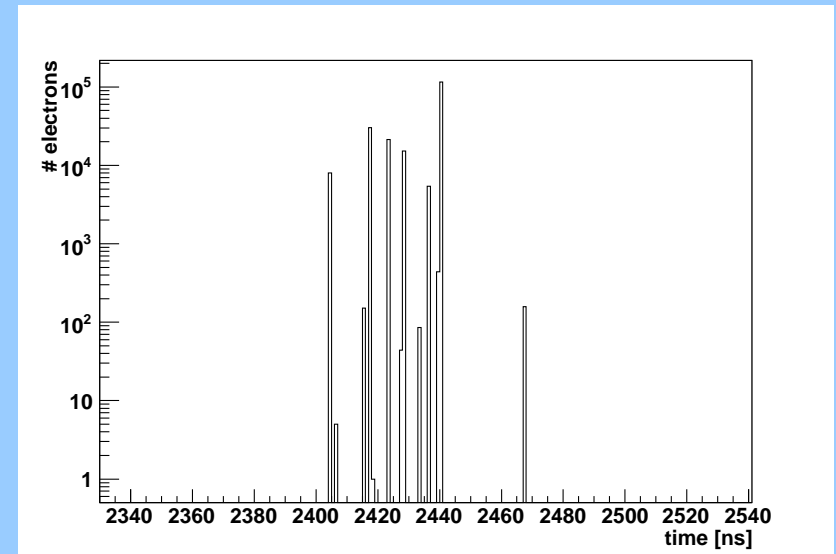
1. Parametrisation of charge transfer in triple GEM structure: collection, gain, extraction
2. Charge broadening only due to diffusion between GEMs
→ Simulate diffusion with Magboltz



- Calculate number of secondary e^- from charge transfer combined with binomial statistics
- Integrate over 2D gaussian with sigma of charge cloud to get charge on pads
→ Voxel information:
charge on channel c
at time t



- Determine center of gravity of charge in time
- Apply shaping function (Gaussian at the moment)
- Fill electrons into time bins
- Normalise charge with ADC range
- Integrate charge for every ADC bin



TPCGEMSimulation v0.01

1. Primary Ionisation

Input File: /MuonEvents_#100_R130

Magnetic Field B: 0 [T]

TPC Radius: 130 [mm]

TPC Drift Length: 260 [mm]

#e- pro Cluster Info File: ts/electronsincluster.dat

3. Amplification and Creation of Voxel

Inputfile: /TPCDrift_B0.0_R130_L260

Pad Width: 2 [mm] Pad Height: 6 [mm]

Number of Pads: 448 Pads in Row: 32

Offset of Padplane to Center of TPC: 0 x [mm] 0 y [mm]

GEM Settings

U GEM 1: 320 [V]

Transfer Field 1: 2500 [V/cm]

U GEM 2: 320 [V]

Transfer Field 2: 2500 [V/cm]

U GEM 3: 320 [V]

Induction Field: 5000 [V/cm]

Parameter File: jew.par.nocomments

Program Output

```

Opened file
/disk1/data/muennich/data/temp/MuonEvents_#100_F
with 100 entries
99787 Events read.
Event 0 with 1 particle(s) and 1909 electrons
TPCIONISATION FINISHED
Opened
/disk1/data/muennich/data/temp/TPCIonisation_B0.0_
Drifting for TDR gas with E=240 V/cm,
dl=283.994 [mum/sqrt(cm)]
v_d=44.7989 [mm/mus]
d_t=475.95 [mum/sqrt(cm)]
1909 electrons on track: 0
DRIFTING FINISHED
Opened
/disk1/data/muennich/data/temp/TPCDrift_B0.0_R130.
Drifting for TDR gas with E=240 V/cm,
dl=283.994 [mum/sqrt(cm)]
v_d=44.7989 [mm/mus]
d_t=475.95 [mum/sqrt(cm)]
448 Pads in 14 rows and 32 columns.
Offset of Active Area in x: 32 in y: 42
Parameter file read successfully
Event 0 done
Entries in tree: 98
MAKING PADS FINISHED
Opened
/disk1/data/muennich/data/temp/TPCPads_B0.0_R130
Output:
TPCShaper_12.5_B0.0_R130_L260_E240_TDR_px2.C
Event 0 with 79 channels
                
```

2. Drift Tracks

Input File: /TPCIonisation_B0.0_R130

Gas: TDR (TDR, P5, P10)

Electric Field E: 240 [V/cm]

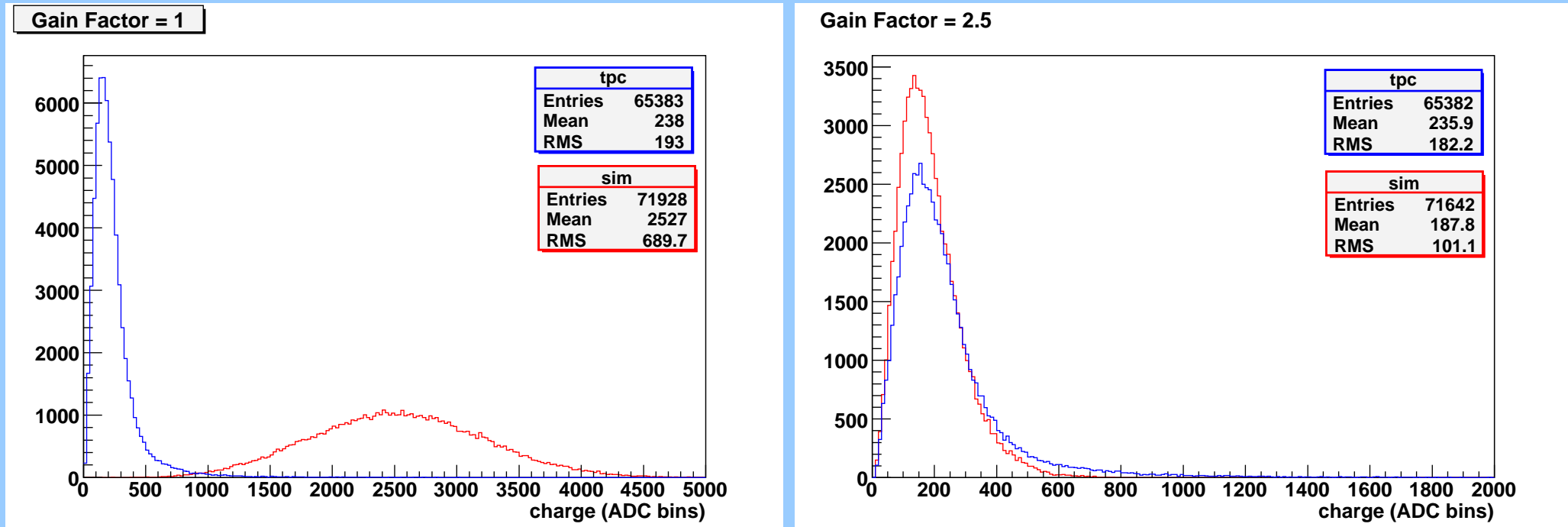
4. TPCElectronics

Inputfile: /TPCPads_B0.0_R130_L260_E240_TDR_px2.C

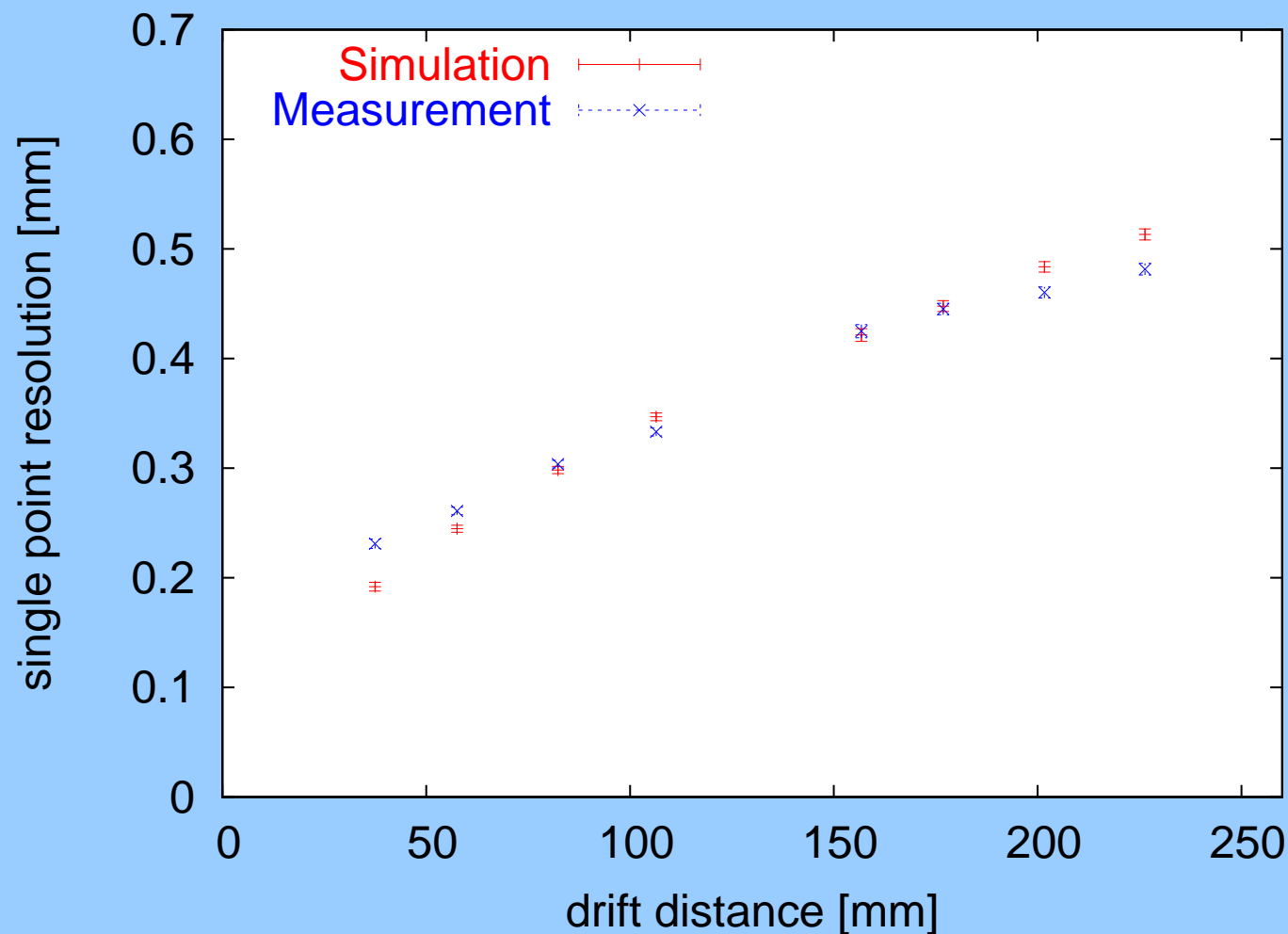
Readout Frequency: 12.5 [MHz] ADC Resolution: 8 [bit]

Rise Time: 300 [ns] max. Charge for ADC: 1000000 [#e-]

Mean gain for one GEM from charge transfer parametrisation to high.
To match charge spectrum from measurement:
Decrease it by factor to account for temperature difference.



$1.27 \times 6.985 \text{ mm}^2$ Pads, TDR Gas, 0T, DESY Testbeam



Advantages:

- Simulation independent from big simulation packages
- Amplification with GEMs (accounts for different settings)
- Magnetic fields and 3D tracks possible
- Many input parameters for systematic studies

Limitation:

- No spatial propagation of δ -electrons during primary ionisation

Outlook:

- Verification of simulation with testbeam data
- Systematic studies for ILC TPC